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Comparative Study on the Flexural Behavior of Asphalt Concrete with Geocomposite

Shyam Kumar. M[1], Manikandan. P[2], Alen JD Reno[3], Manikandan. M[4], Jebin. J[5], Dr. Malarviji[6]
[1]*Assistant Professor, Department of Civil Engg., Loyola Institute of Technology, Chennai*
[2, 3, 4, 5]*Under Graduate Students, Department of Civil Engg., Loyola Institute of Technology, Chennai*
[6]*Associate Professor, Department of Civil Engg., Loyola Institute of Technology, Chennai*

Abstract: ***The Concrete is the trunk or the foundation for building the structures. The properties of the Concrete plays an indispensable role in developing the strength of the Concrete. So in order to upsurge the strength properties some inclusion of materials or supplant for the Concrete elements has to be contrived. The most frequent failure types of asphalt pavements that occur at low temperatures are transverse cracks are mainly caused by tensile stresses in the asphalt layers. In terms of reinforcement, by using geogrids or geocomposites between asphalt layers, is possible to increase fatigue resistance, reduce rutting and limit reflective cracking. Therefore an endeavor of study has been made based on the Strength and comparison of Conventional Concrete with the Combination of Asphalt and Geocomposite Concrete. In this experiment the Asphalt is utilized as a partial replacement of Cement and with addition of utilizing Geomembranes in Concrete with different properties of study conducted on the M25 Concrete mix. The usage of Asphalt and Geomembranes result in the variation of strength and flexural properties of Concrete. The Compression test and the flexural test is used to determine the behaviour of Concrete when it is subjected to the external loads. Various percentage of Asphalt Concrete of about 10% to 20% is casted and compared with the Conventional Concrete.***

Keywords: ***Asphalt Concrete, Flexural Strength, Geocomposite***

I. INTRODUCTION

Concrete is the essential material which is used in the Construction sector. There are disparate types of Concrete used now a days such as Reinforced Concrete, Prestressed Concrete, Precast Concrete, High density Concrete, Air entrained Concrete, High strength Concrete, High performance Concrete etc. Based on the grade of Concrete mix the category and strength of the Concrete and its properties also varies. Most of the massive construction works undergoes with the usage of High performance and High strength Concrete so in order to develop the strength of Concrete some elements in the Concrete is partially replaced or fully replaced. By replacing some of the ingredients in Concrete there will be explicit changes in the properties of the Concrete.

In this experimental study the Geomembranes and Asphalt is used as the partial replacing materials in the Concrete. Geomembranes are water proof components used in Construction of sewer lines and also used in the Foundations of structures. There are various design of Geomembranes such as Geomembrane layers and Geomembrane Grid. Geomembranes also has various properties such as Tear resistance, tensile strength, Interface shear strength, Anchorage strength and stress cracking etc. Geomembranes are the best water resisting materials. The Geomembrane sheets are used in this research in order to achieve additional strength and to increase the mechanical properties of the Concrete. The Geomembranes are used as the additional materials for increasing the strength of the Concrete. Similar to Geomembrane layers the Geogrids made of polymeric coated sheets are used for the replacement of reinforcements provided in the Concrete. Asphalt is an exceptionally viscous material and it is a partly solid form of Petroleum. It is found typically in a discriminating state. The Asphalt is chiefly used in the Road construction works. The dominant use of Asphalt in the road constructions is 70%. It is used as a binder which is mixed with the aggregate particles in order to obtain the Asphalt Concrete. The Asphalt provides proper bond strength to the Aggregates and Reinforcement thereby increasing the Strength and Durability of the Concrete. One of the most recurrent failure types of asphalt pavements that occur at low temperatures are transverse cracks. Geogrids can be employed to reinforce the pavement base or asphalt cap and also used to avoid pumping of fines from the base or subgrade through cracks in the asphalt cap and act as barriers to reduce pavement base saturation. The efficiency of reinforcement is erroneously identified with increasing the Asphalt Concrete stiffness. The interaction mechanism between a geosynthetic reinforcements and an asphalt layer depends on several factors (properties of materials, loading conditions, temperature etc.). In this experiment 10% and 20% of Asphalt mixed Concrete Cubes and cylinders are casted and compared with conventional concrete to fiind Compressive strength and Tensile strength of the Concrete specimens. For determining the flexural strength of concrete, the beam is casted and tested after 28 days of curing.

II. OBJECTIVES

A. The main intend of this project is to assure the most optimum proportions of the constituent materials to fulfill the requirement of the structure being built.
B. To accomplish the desired minimum strength in the hardened stage.
C. To develop concrete as economically feasible.
D. To find out the optimum percentage of additional of various percentage of Asphalt with conventional Concrete.
E. To evaluate the effect of Geogrid on the mechanical properties of asphalt mixtures
F. To know the strength variations by comparing conventional concrete with Asphalt Concrete.

III. MATERIALS USED AND THEIR PROPERTIES

The most common ingredients used in this mix design project are,

A. Geomembrane

The Geomembranes are Water proof materials which are broadly used for resisting water penetration. They are used in vast area of construction due to their synthetic bonding which makes them highly impervious in nature. There are wide variety of geomembranes and the important among them are polyvinyl chloride (PVC), polypropylene, linear low-density polyethylene (LLDPE), and medium-density polyethylene (MDPE).They can be used as a reinforcement as well as a detaching material.
The Geomembrane sheets are used in the form of individual, dual or composite liners. The Geomembranes are mostly used in the base liners. Geogrids are manufactured from polymeric coated polyester component which has increased tenacity, molecular weight and poor carboxyl end group polyester yarns. It is meshed to form grid structures. It has a minimum Thickness of 1.5 mm, Sheet Density having 0.95 mm and with an Asperity height of 0.252 mm.

B. Asphalt petroleum Bitumen Grade 60/70

Bitumen 60/70 is semi hard penetration grade bitumen suitable for road construction and for the asphalt pavements with superior properties. This type of bitumen used in the manufacture of hot mix asphalt for bases and wearing courses. The penetration grade bitumen is refinery bitumen that is manufactured at different viscosities. The penetration test is carried out to characterize the bitumen, based on the hardness.
Thus, it has the name penetration bitumen. The penetration bitumen grades range from 15 to 450 for road bitumen. The bitumen is provided during the process of oxidation of vacuum bottom in bitumen production units. Penetration grade bitumen 60/70 has penetrated between 60~70 Desi-millimeters and softening purpose between 48 ~ 52°C. The penetration grade bitumen 60/70 has a thermoplastic property that is like as synthetic resin material that gets softer with heating and hardens once cooled. This grade of bitumen 60/70 has a terribly strong viscosity compare to alternative grades.
Asphalt is a black colored exceptionally viscous material and a partial solid form of Petroleum. It is found commonly in a discriminating state. The dominant use of Asphalt in the road constructions is 70%. Asphalt has a density of 2243 kg/m^3 and having moisture content up to 6%. The chemical constituents such as Carbon (83.77%), Hydrogen (9.91%), Nitrogen (0.28%) and Sulphur (5.25%) is found in Asphalt. It is used as a binder which is mixed with the aggregate particles in order to obtain the Asphalt Concrete. The Asphalt provides proper bond strength to the Aggregates and Reinforcement thereby increasing the Strength and Durability of the Concrete.

C. Cement

Cement is a covering or a binding material which helps to hardens for the proper bonding between the Reinforcement and other ingredients of the Concrete mix. The grade of the Cement used in this experimental study is OPC (Ordinary Portland Cement) 53 grade Cement.

D. Coarse Aggregates

The Coarse aggregates are the tough aggregates which having a rugged surface and hard lucid structure. It has a size greater than 4.75 mm tested during Sieve analysis. The Coarse aggregates are used to increase the strength and volume of the Concrete structures. The Size of the Coarse aggregate which we use in this study is 20mm aggregate. Properties of coarse aggregate like Water absorption and specific gravity are tested in accordance with IS: 2386

E. Fine Aggregates

The fine aggregates are the aggregates which are very fine and minute in structure. The fine aggregates are the aggregates which having a size lesser than 4.75 mm tested during the sieve analysis. The fine aggregates helps to reduce the air voids inside the concrete and aids in increasing volume and strength of the Concrete structures. Usually river sand is used as the fine aggregate conforming to IS: 383 – 1970 but due to greater demand of fine aggregate M sand is used as the fine aggregate.

IV. EXPERIMENTAL INVESTIGATION

A. Mix Proportion

The Concrete mix design helps in determining the minimum strength and durability of the Concrete. It is a process of determining various Raw materials used for improving the Performance of the Concrete mix. The mix design is used to identify and determine the minimum Compressive strength, Tensile strength and flexural strength required for the Structural Consideration. The type of mix used in this study is the design mix of M25 Concrete as per IS 10262:2009. The mix adopted for the Concrete is given in the Table 1.

Table 1 Mix Proportion

Cement	Fine Aggregate	Coarse Aggregate	W/C Ratio
1	1.54	2.78	0.45

B. Details Of Specimen Preparation

Table 2 Specimen Preparation Details

MIX ID	MATERIAL DESCRIPTION	% OF REPLACEMENT
CC	CONVENTIONAL CONCRETE	0%
AC	ASPHALT CONCRETE	10% & 20% of Cement by Asphalt
CGC	CC + GEOPOLYMER GRID AS STIRRUPS	-
AGC	AC + GEOPOLYMER GRID AS STIRRUPS	Optimu 20% of asphalt + Geogrid as Stirrups

C. Casting Of Specimens

The Casting of specimens is initially started by batching, mixing, compaction, placing and finally curing is done. Mixing may be done by either hand mix or machine mix for mixing the Concrete. After mixing the Concrete, it is then placed into the Concrete moulds and these moulds are corresponded with three layers of the Concrete mix and it is tamped upto 25 times with the help of a tamping rod for Compaction and finally it is cured for 7, 14 and 28 days.

1) *Cube:* The mould size used for cazsting the Concrete Cubes are 150 mm x150 mm x150 mm.
2) *Cylinder:* The mould size used for casting the Concrete cylinders are 150mm x 300mm.
3) *Beam:* The mould size used for casting the Concrete Beam are 150 mm x 150 mm x550mm.

Fig. 1 During Preparation & Casting of Specimen

D. Curing Of Specimens

The Casting of specimens is initially started by batching, mixing, compaction, placing and finally curing is done. Mixing may be done by either hand mix or machine mix for mixing the Concrete. After mixing the Concrete, it is then placed into the Concrete moulds and these moulds are corresponded with three layers of the Concrete mix and it is tamped up to 25 times with the help of a tamping rod for Compaction and finally it is cured for 7, 14, 28 days..

E. Experimental Setup

The Experiments were done in a UTM loading machine as shown in Fig 2. It has two support points with a moving rail on the cart. The distance between these 2 supports was set to 500 mm. Three-point loading system was applied two point loads at the ends and the other is applied on the center to the top of the beam. Steel rod having 20 mm thickness were used for loading on the loading zones of the Concrete beam.

Fig.2 Experimental Setup for Flexural Strength of Beam

F. Reinforcment Details

The Cross sectional details and longitudinal section details of RCC beams are shown in fig 2.

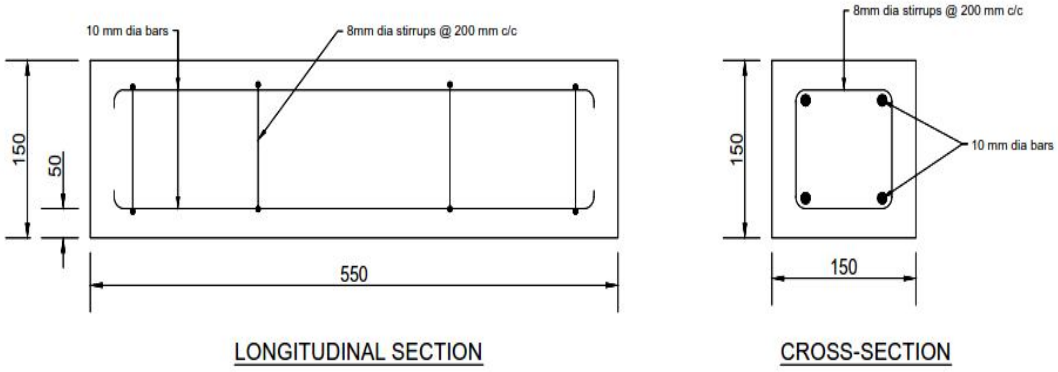

Fig.3 Reinforcement Detailing of RCC Beam

G. Preparation of Asphalt Concrete Beams

Bitumen grade 60/70 binder was used in the preparation of the Asphalt concrete. The asphalt concrete beams were moulded by static compression in a rigid container. The beams were 550 mm long, 150 mm wide and 150mm thick (Fig. 2). For the asphalt concrete beam preparation the aggregate and the bitumen 60/70 grade were heated at temperatures of 150° for period of 25 minutes to get a homogeneous binder prior to mixing. The aggregate used to prepare the beams had particle diameters smaller than 25 mm.

V. RESULTS AND DISCUSSION

A. General

The general hardened Concrete test such as the Compressive test, Split tensile test and Flexural Test of the Concrete specimens. These tests helps in determining the load carrying capacity of the Concrete specimens.

B. Test on Hardened Concrete

The hardened Concrete test plays an important role in controlling the quality of Concrete works by conducting the test such as Compressive test, Split tensile test and Flexural test on Concrete Cubes, Cylinders and Concrete Beams for 7, 14 and 28 days in order to determine the Ultimate strength of Casted Concrete Beam.

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1) *Compressive Strength:* In this experimental investigation totally 54 cubes of 150 mm x 150 mm x 150 mm size were casted and after curing period of 7, 14 and 28 days, the cubes were tested in compression test machine . The cube test was conducted as per IS 516: 1959. The test result are shown graphically in Fig .3. From Compressive strength result, when comparing CC with AC concrete cubes we came to know that the Optimum value is 20% of Asphalt Concrete. The Compressive Strength of AC Concrete is 30% more than that of Conventional Concrete as shown in Fig.4.

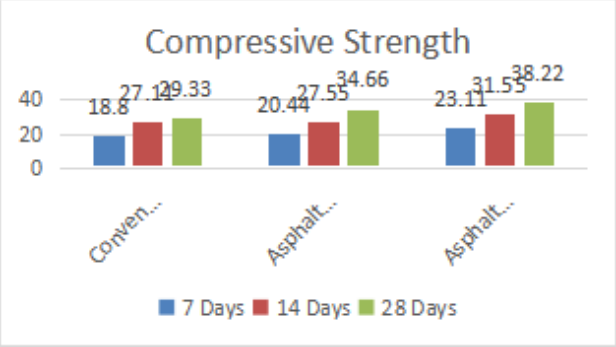

Fig. 4 Comparison on Compressive strength of Concrete

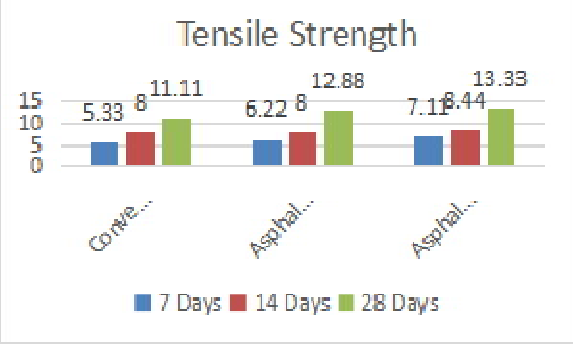

Fig. 5 Comparison on Split Tensile strength of Concrete

2) *Tensile Strength:* In this experimental investigation totally 54 cylinders of size 150 mm and 300 mm diameter & length were casted and after curing period of 7, 14 and 28 days, the cylinders were kept horizontal tested under Compression testing machine and the Split tensile test was performed. The split test was conducted as per IS 516: 1959. The test results shown that Split Tensile Strength of AC Concrete is 20% more than that of Conventional Concrete are shown graphically in Fig .5.

3) *Flexural Strength:* The Concrete Beams are casted in order to determine the Flexural strength of the Concrete based on the design mix which we have adopted. Totally 3 types of Concrete beams are casted in order to compare the flexural results. The center point load is applied for flexural test.

The Flexural strength or rupture modulus is calculated by using the following formula

$$\text{Rupture modulus} = 3\ PL / 2\ bd^2 \quad N/mm^2$$

The 3 types of Concrete beam design are,

a) Conventional Concrete Beam **(CC)**:

b) Asphalt Concrete Beam **(AC)**: The Optimum Asphalt Concrete mix consists of 20% of Asphalt Concrete in addition to reinforcement of the Concrete beam.

c) Conventional concrete along with Geogrid reinforcement Beam **(CGC)**: In this Beam, the Conventional Concrete mix is placed in the mould and the reinforcement is provided with a cover thickness of 50mm and the stirrups provided for the reinforcement is fully replaced with Geogrid in the spiral formation.

d) Asphalt concrete (optimum 20%) along with Geogrid reinforcement Beam **(AGC):** In this Beam, the Asphalt Concrete mix is placed in the mould and the reinforcement is provided with a cover thickness of 50mm with Geogrid has been used as shear reinforcement in the spiral form.

The flexural behavior of RCC beams of above 3 different combinations of M25 grade concrete were calculated & results are shown graphically in Fig.6.

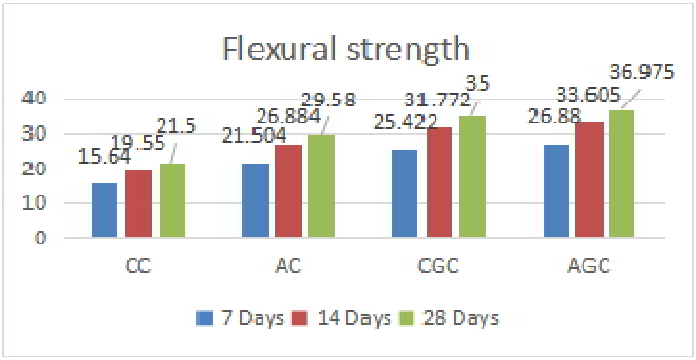

Fig.6 Comparison on Flexural Strength of Concrete Beams

Fig.6 Failure mode of beam during Flexural Strength Test

VI. CONCLUSION

A. Replacement of cement by Asphalt is found to increase in the strength of concrete. The optimum dosage for partial replacement of cement by Asphalt is 20%.

B. The compressive strength, tensile strength and flexural strength of concrete increases with increase in Asphalt and Geomembrane content.

C. By the addition of 20% of Asphalt, the Compressive strength is 30 % more when compared with conventional concrete.

D. By the addition of 20% of Asphalt, the split tensile strength is 20 % more when compared with conventional concrete.

E. The ultimate load and flexural strength is increased by 1.38 times for AC and 1.65 times for CGC when compared to CC.

F. The flexural strength of AGC is increased by 25% when compared to AC.

G. While testing a flexural strength, conventional concrete specimen's shows a typical cracking pattern, but AGC concrete beam show reduced crack. This shows that the ductile behavior due to the presence of Asphalt and Geomembrane grid.

H. Crack reflection was observed in all tests performed, but it was considerably more severe in the conventional case.

I. The most frequent failure types of asphalt pavements that occur at low temperatures are transverse cracks are mainly caused by tensile stresses in the asphalt layers. In terms of reinforcement, by using geogrids or geocomposites between asphalt layers, is possible to increase fatigue resistance, reduce rutting and limit reflective cracking.

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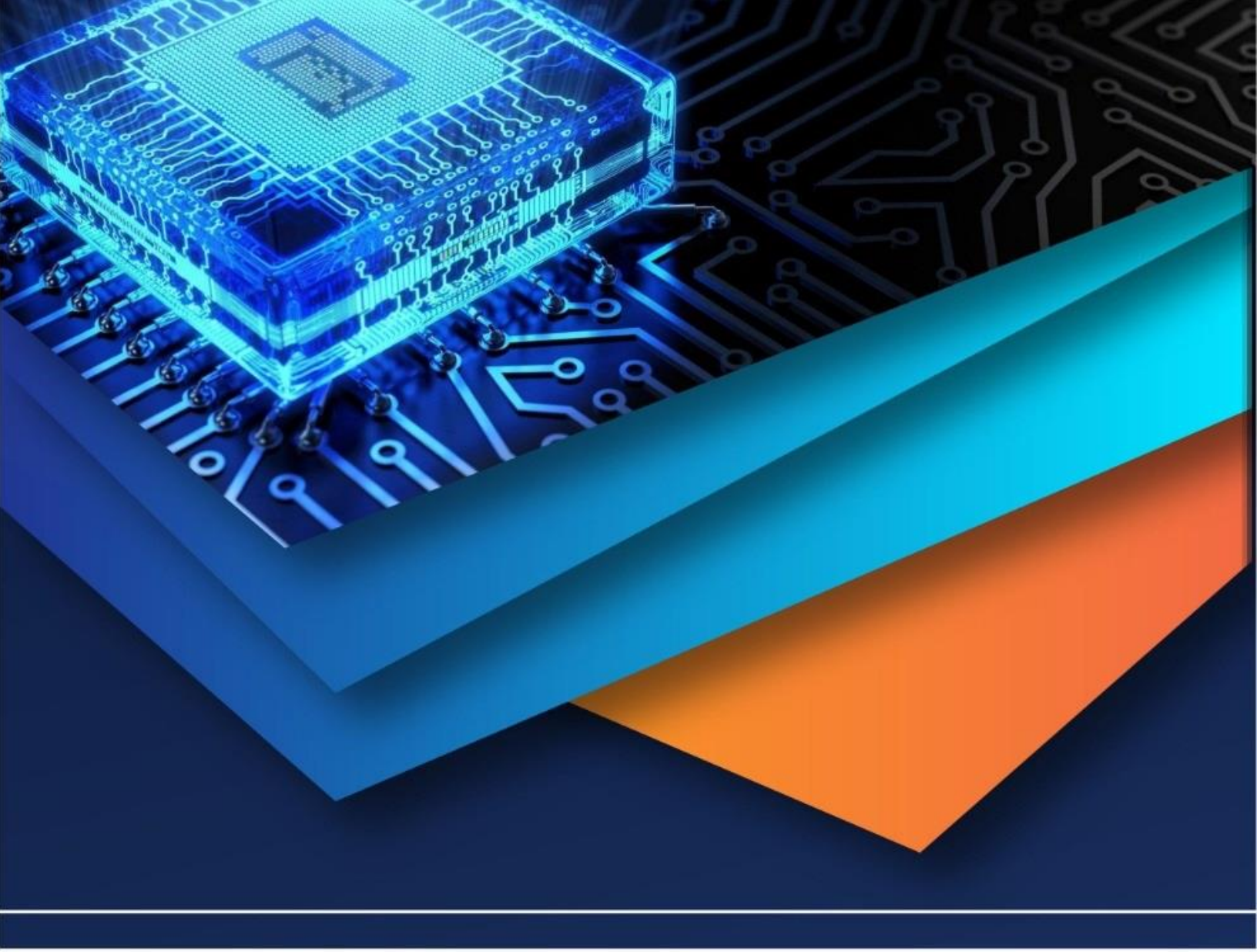

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